Carbon nanotubes in microfluidic devices for chemical analysis

Mogensen, Klaus Bo

Published in:
36th International Symposium on High-Performance Liquid Phase Separations and Related Techniques

Publication date:
2011

Document Version
Publisher's PDF, also known as Version of record

HPLC 2011 abstract

Carbon based nanoporous sorbents are extensively used as separation media in chromatography, due to a very high surface-to-volume ratio, favorable molecular interaction properties, and high stability. Various forms of graphitized carbon have been widely used over the past decades, but only recently also carbon nanotubes have been exploited as a stationary phase. This has typically been done by acquiring nanotubes in powder form, dissolving them in a porous polymer matrix, and filling this mixture into fluidic channels.

In this work, carbon nanotubes are grown directly inside glass-based microfluidic channels by chemical vapor deposition from a metal catalyst layer. This significantly simplifies the fabrication process compared to manual loading of the stationary phase, because deposition and growth on several devices can be done in parallel. It furthermore ensures attachment of the nanotubes to the fluidic channel wall, which avoids the need for integrated frits. Photolithographic patterning of the stationary phase is also possible following this approach, thereby providing additional control of the geometrical features.

One complication of using carbon nanotubes for electrochromatographic applications is that they are highly electrically conducting, which severely limits the electrical field that can be applied over the column before gas bubble formation from electrolysis occurs. When a continuous layer of carbon nanotubes is used, only around 100 V/cm can be applied thus significantly limiting the electroosmotic flow (EOF), which is typically exploited for bulk transport of the mobile phase.

We address this limitation by photolithographic patterning of the catalyst layers in order to grow the nanotubes in an array of micrometer sized pillars. This design ensures that nanotubes in adjacent regions are not in electrical contact with each other, which significantly reduces the conductivity of the nanotube column. This makes it possible to apply an electric field strength of more than 2 kV/cm without bubble formation from electrolysis of the aqueous buffer solution. This is more than 1 order of magnitude higher than what has been achieved previously, and is necessary in order to provide sufficient flow rates during the separation, and consequently offer enough freedom to adjust the flow rate for performance optimization.